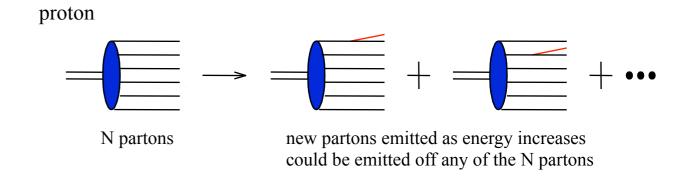
F_L and F₂ - theory model comparison with HERA data

Matthew A. C. Lamont BNL

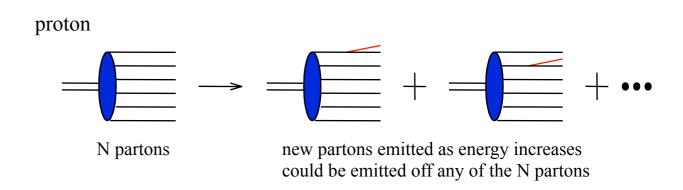


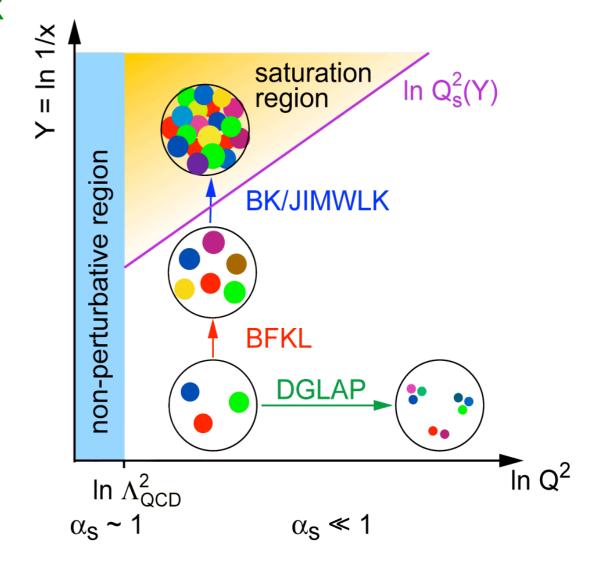
Non-linear QCD - Saturation



Non-linear QCD - Saturation

- BFKL: evolution in x
 - → linear
 - explosion in colour field at low-x





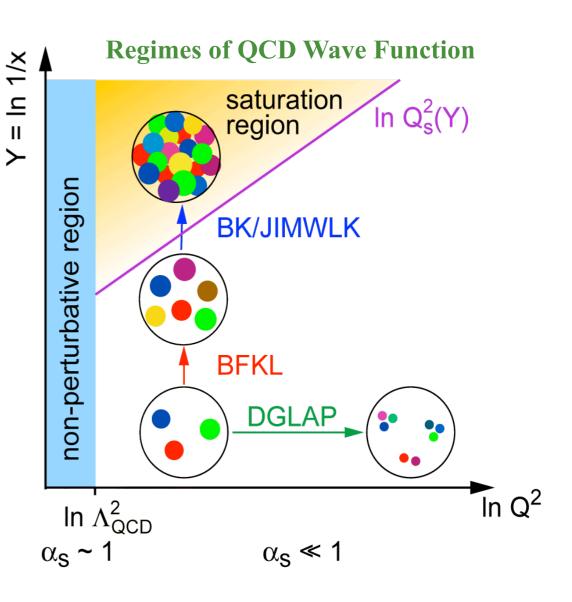
Non-linear QCD - Saturation

- BFKL: evolution in x
 - → linear

- Proton

 N partons

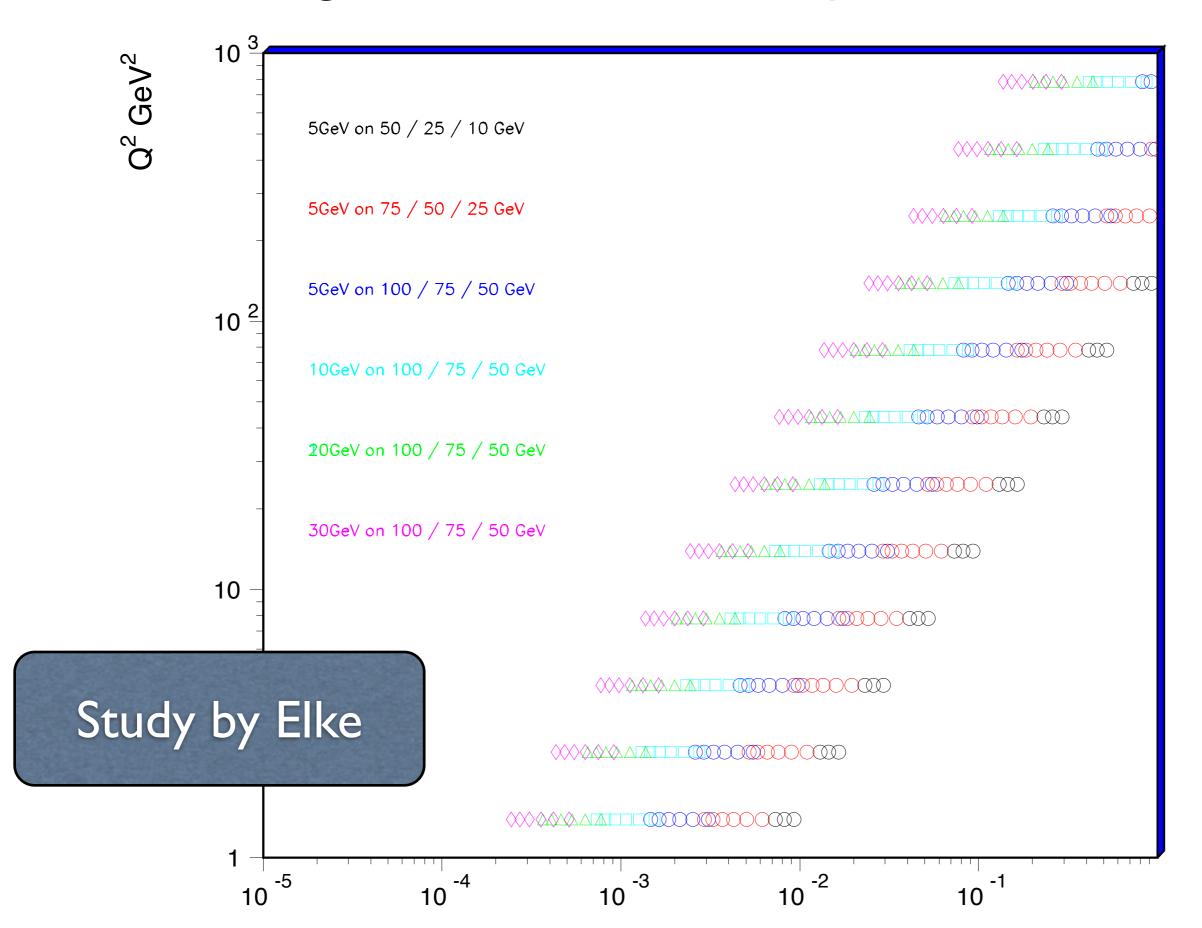
 any 2 partons can recombine into one
- explosion in colour field at low-x
- Non-linear BK/JIMWLK equations
 - → non-linearity ⇒ saturation
 - Allows for the recombination of gluons in a dense gluonic medium
 - characterised by the saturation scale, Q_S(x,A)



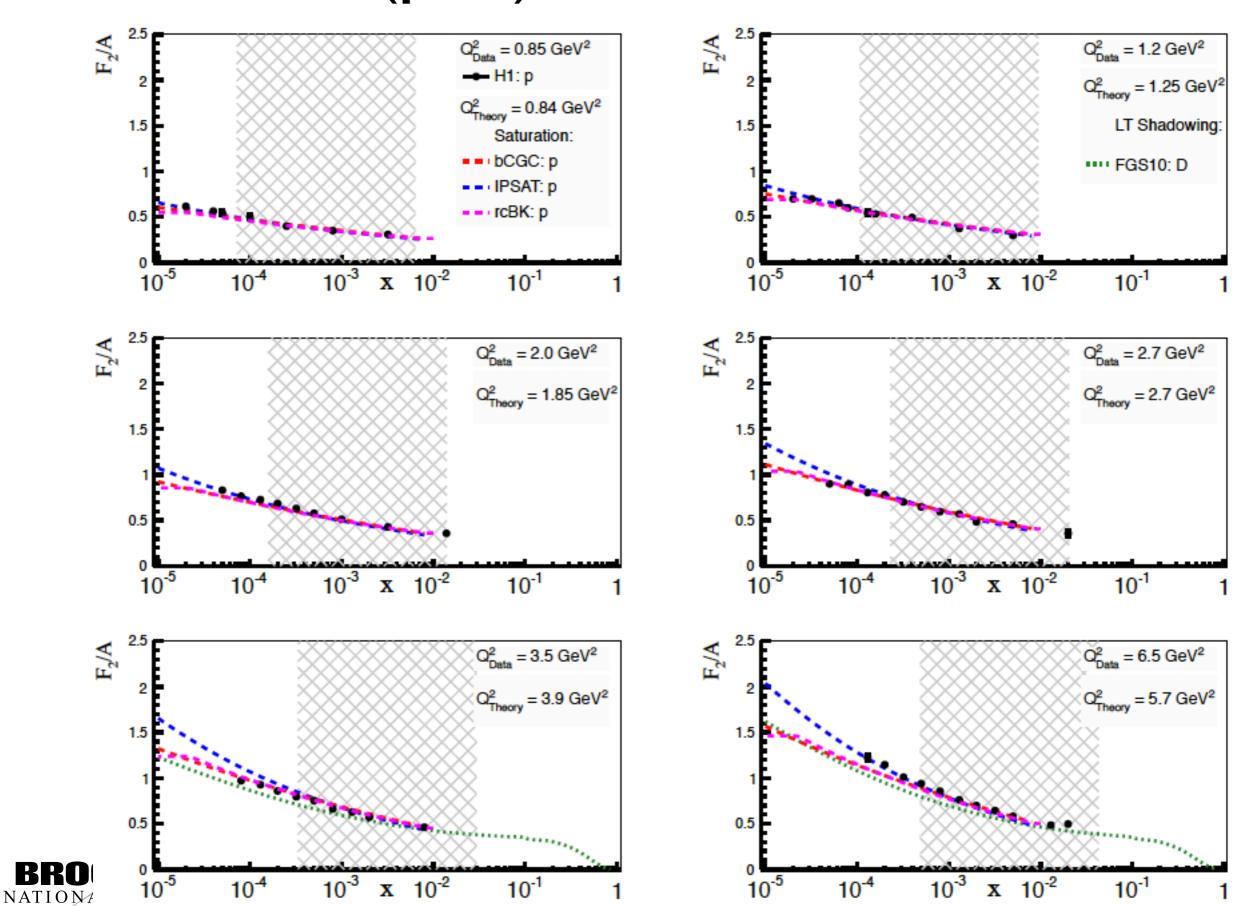
Explanation of what's on the plots...

- Theory
 - Leading-Twist Shadowing
 - FGS10 provided by Vadim Guzey
 - Evolved with a DGLAP evolution
 - → Saturation, dipole models
 - IPSat provided by Tuomas Lappi (work by Henri Kowalski, Graeme Watt)
 - Evolved with a DGLAP evolution
 - Fit to ZEUS 96 data χ^2 /d.o.f. ~ 1.2
 - <u>bCGC</u> provided by Tuomas Lappi (work by Henri Kowalski, Graeme Watt)
 - "ad-hoc" approach to evolution but based on BK
 - Fit to ZEUS 96 data $\chi^2/d.o.f = 1.62$
 - rcBK provided by Javier Albacete (AAQMS model)
 - Evolution along x with BK equation
 - Fit to H1+ZEUS combined 2006 data
- Experimental Data
 - → F₂: H1&ZEUS combined data from: http://www-h1.desy.de/psfiles/papers/desy09-158.pdf
 - → F_L: H1&ZEUS combined data from: http://www-h1.desy.de/psfiles/papers/desy10-228.pdf

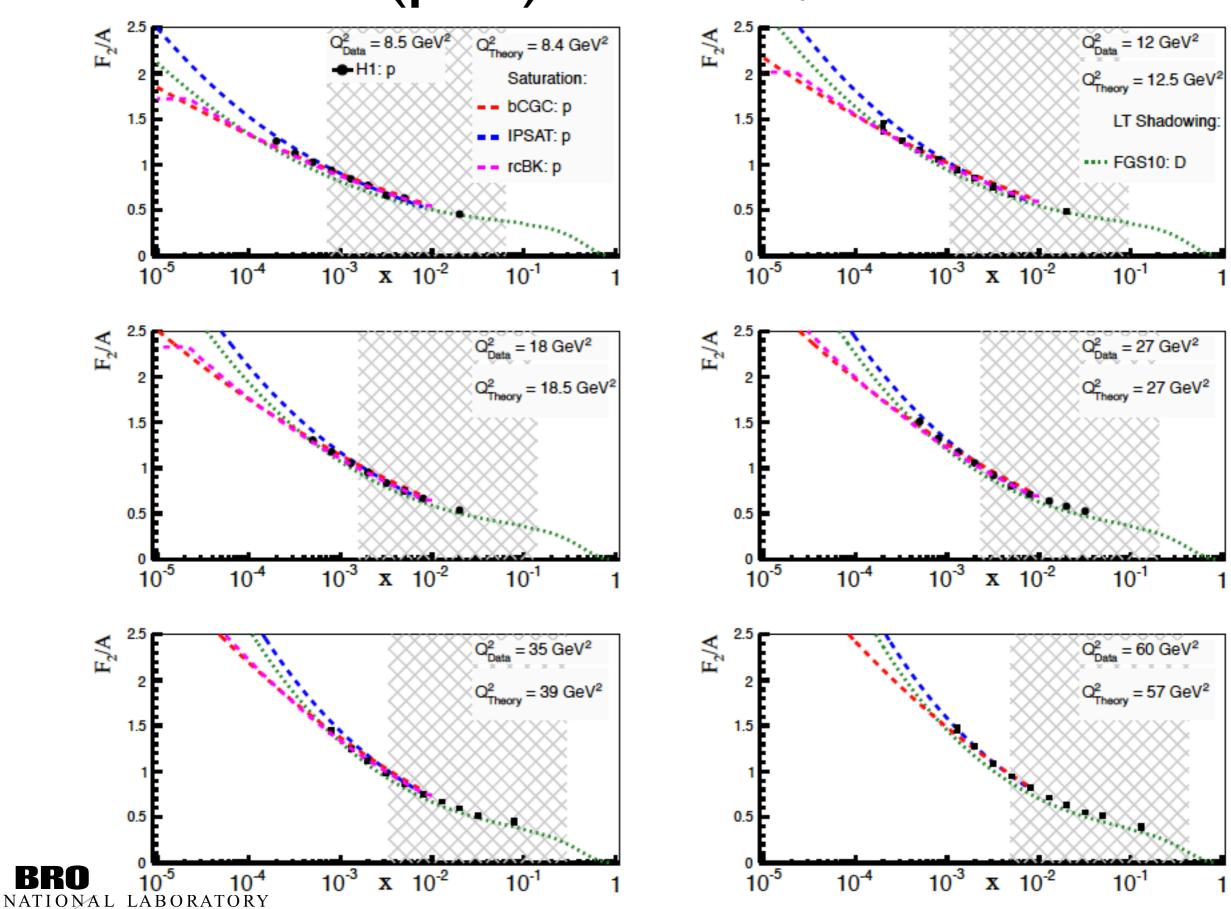
Hatched region - our x-Q² acceptance for F_L and F₂



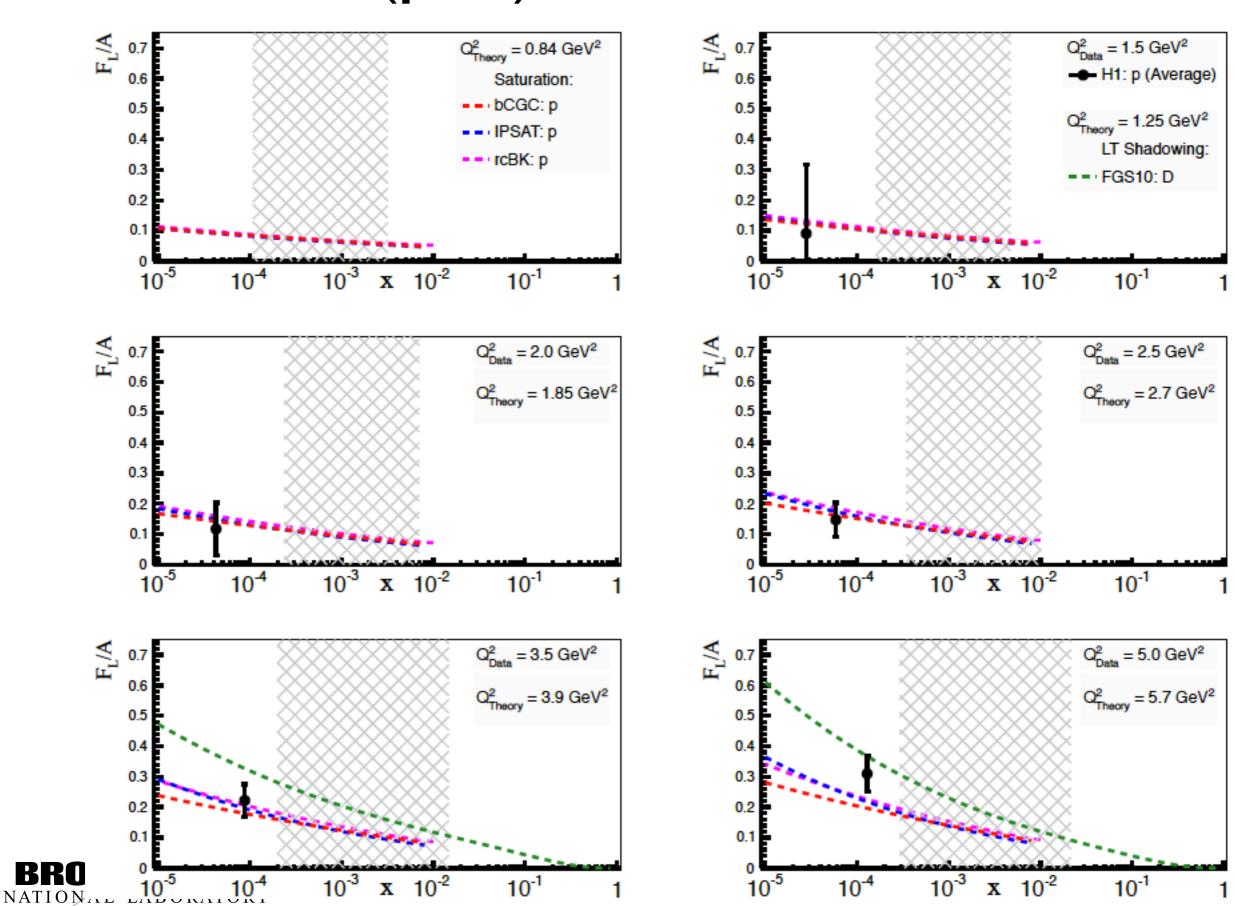
$F_2(p,D) - 0.8 < Q^2 < 6$



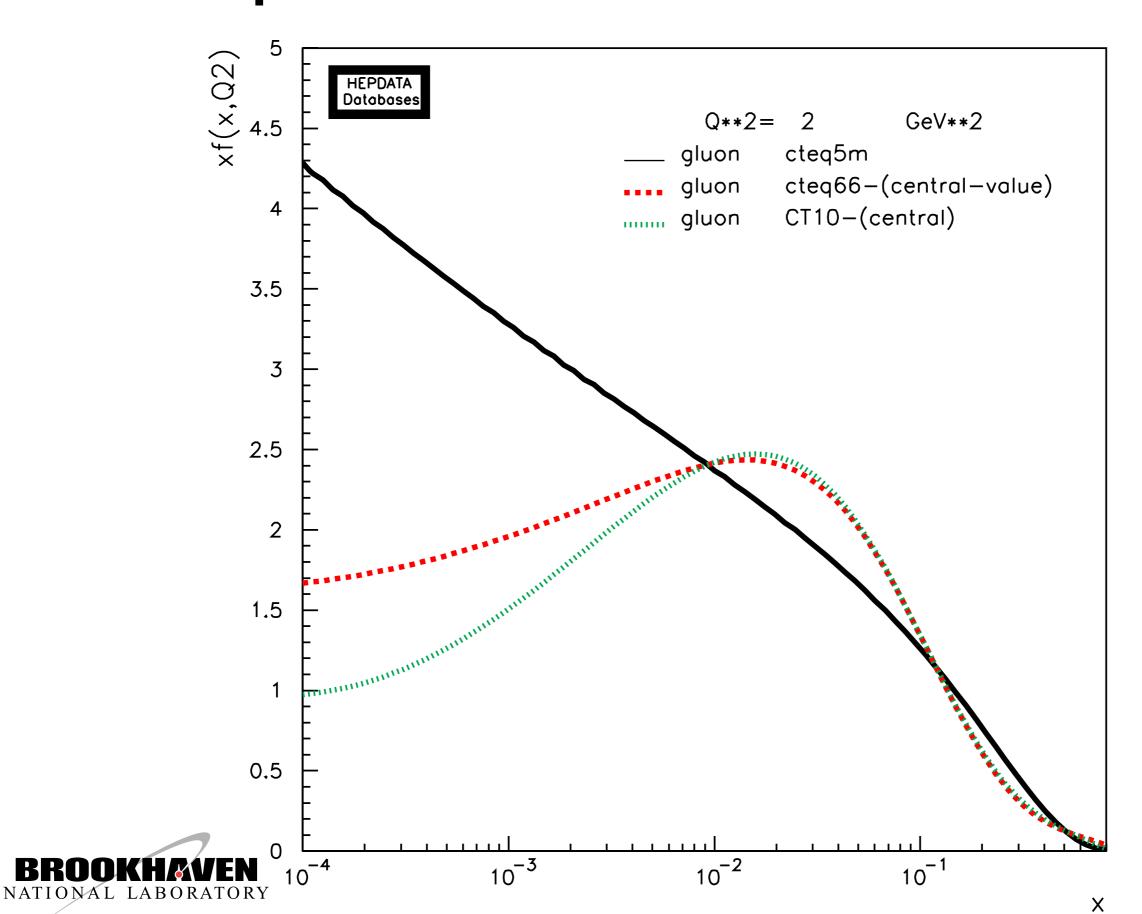
$F_2(p,D) - 8 < Q^2 < 60$



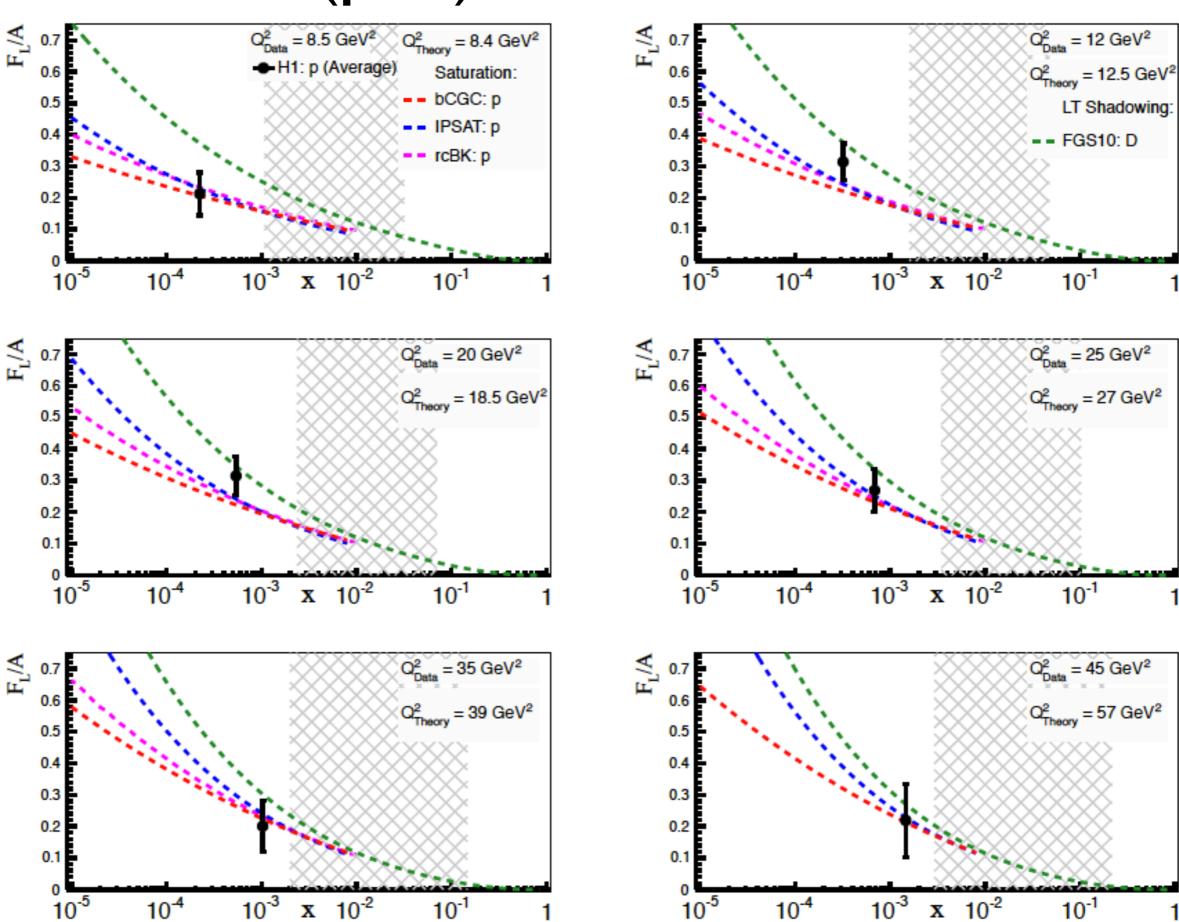
$F_L(p,D) - 0.8 < Q^2 < 6$



Input PDFs in FGS10 model

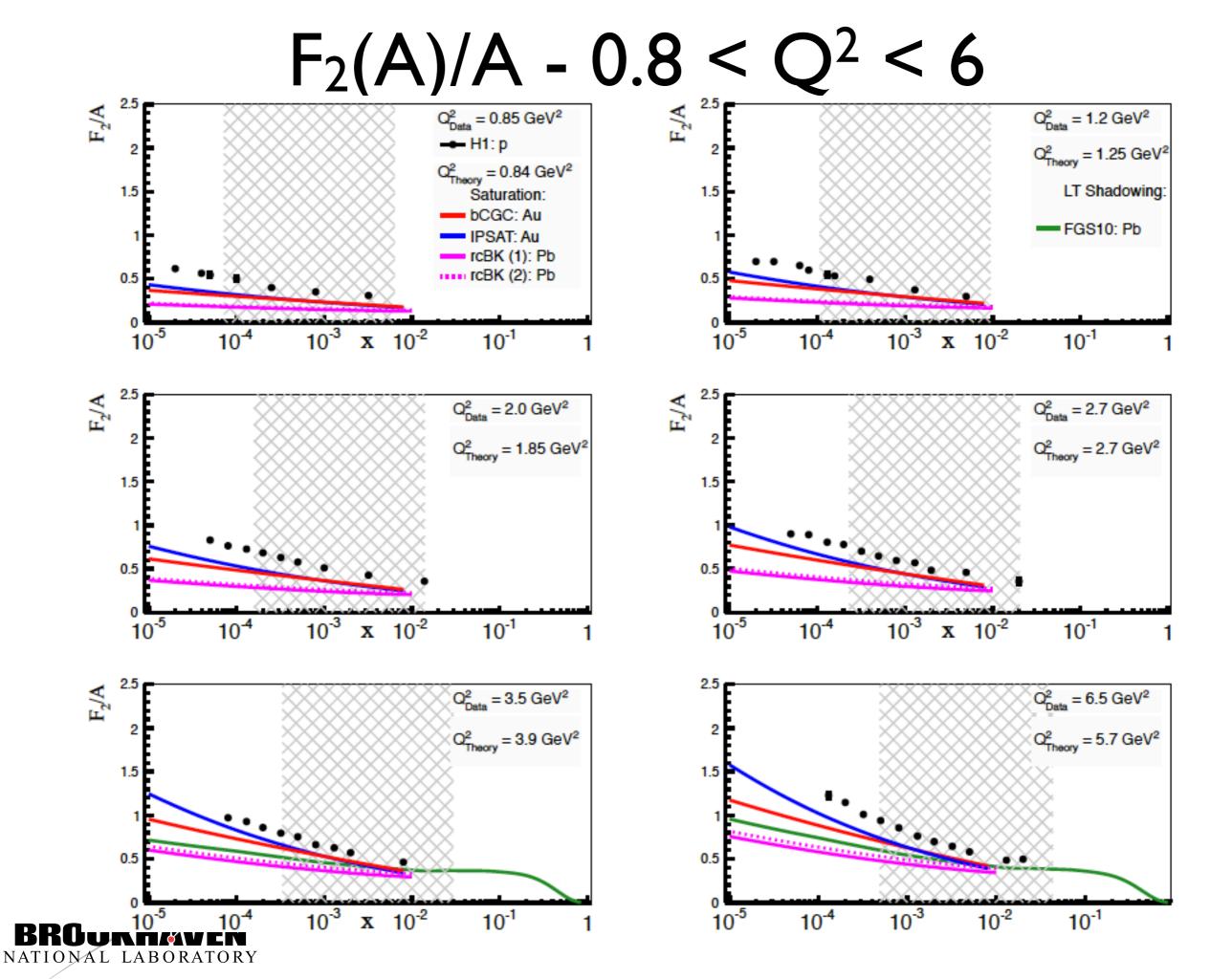


$F_L(p,D) - 8 < Q^2 < 60$

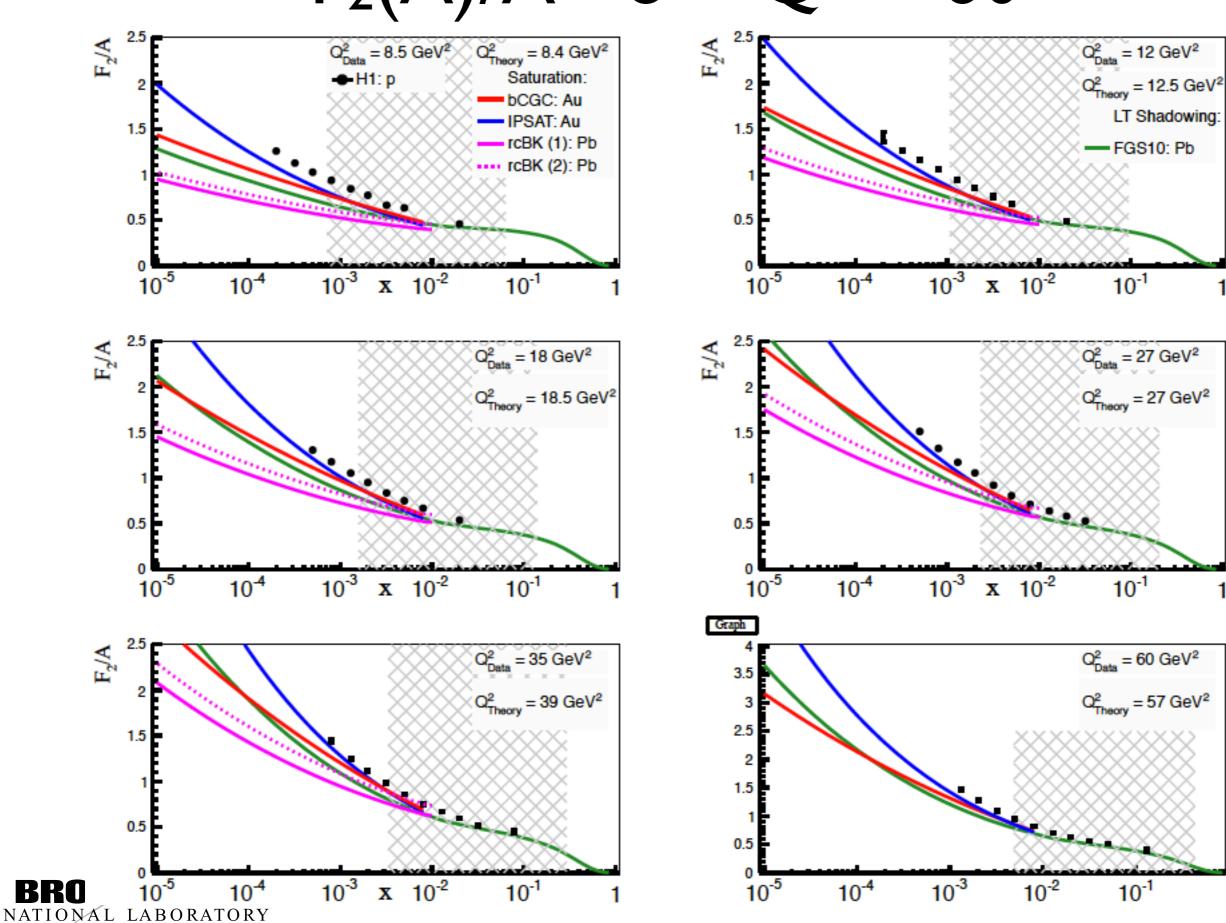


BR

NATIO



$F_2(A)/A - 8 < Q^2 < 60$



$F_L(A)/A - 0.8 < Q^2 < 6$ ∯₁ 0.7 $Q_{\text{Theory}}^2 = 0.84 \text{ GeV}^2$ $Q_{Data}^2 = 1.5 \text{ GeV}^2$ Saturation: --- H1: p (Average) 0.6 bCGC: Au 0.5 - IPSAT: Au $Q_{\text{Theory}}^2 = 1.25 \text{ GeV}^2$ rcBK (1): Pb 0.4 LT Shadowing: ···· rcBK (2): Pb 0.3 FGS10: Pb 0.2 0.1 10⁻³ 10⁻³ x 10⁻² 10⁻¹ 10⁻⁵ 10-4 x 10⁻² 10⁻⁴ 10⁻¹ Y 0.7 $Q^2_{Data} = 2.5 \; GeV^2$ $Q_{Data}^2 = 2.0 \text{ GeV}^2$ 0.6 $Q_{Theory}^2 = 1.85 \text{ GeV}^2$ $Q_{\text{Theory}}^2 = 2.7 \text{ GeV}^2$ 0.5 0.4 0.3 0.2 0.1 10⁻³ 10⁻³ 10⁻⁵ 10⁻⁴ x 10⁻² x 10⁻² 10⁻¹ 10-4 10⁻¹ F, 0.7 $Q_{Data}^2 = 3.5 \text{ GeV}^2$ $Q_{Data}^2 = 5.0 \text{ GeV}^2$ 0.6 $Q_{\text{Theory}}^2 = 3.9 \text{ GeV}^2$ $Q_{\text{Theory}}^2 = 5.7 \text{ GeV}^2$ 0.5 0.4 0.3 0.2 0.1 10⁻³ 10⁻⁵ 10-4 x 10⁻²

 $F_{\rm L}/A$

0.7

0.6

0.5

0.4

0.3

0.2

0.1

0.7

0.6

0.5

0.4

0.3

0.2

0.1

0.7

0.5

0.4

0.3

0.2

0.1

NATIONAL LABORATORY

10⁻⁴

x 10⁻²

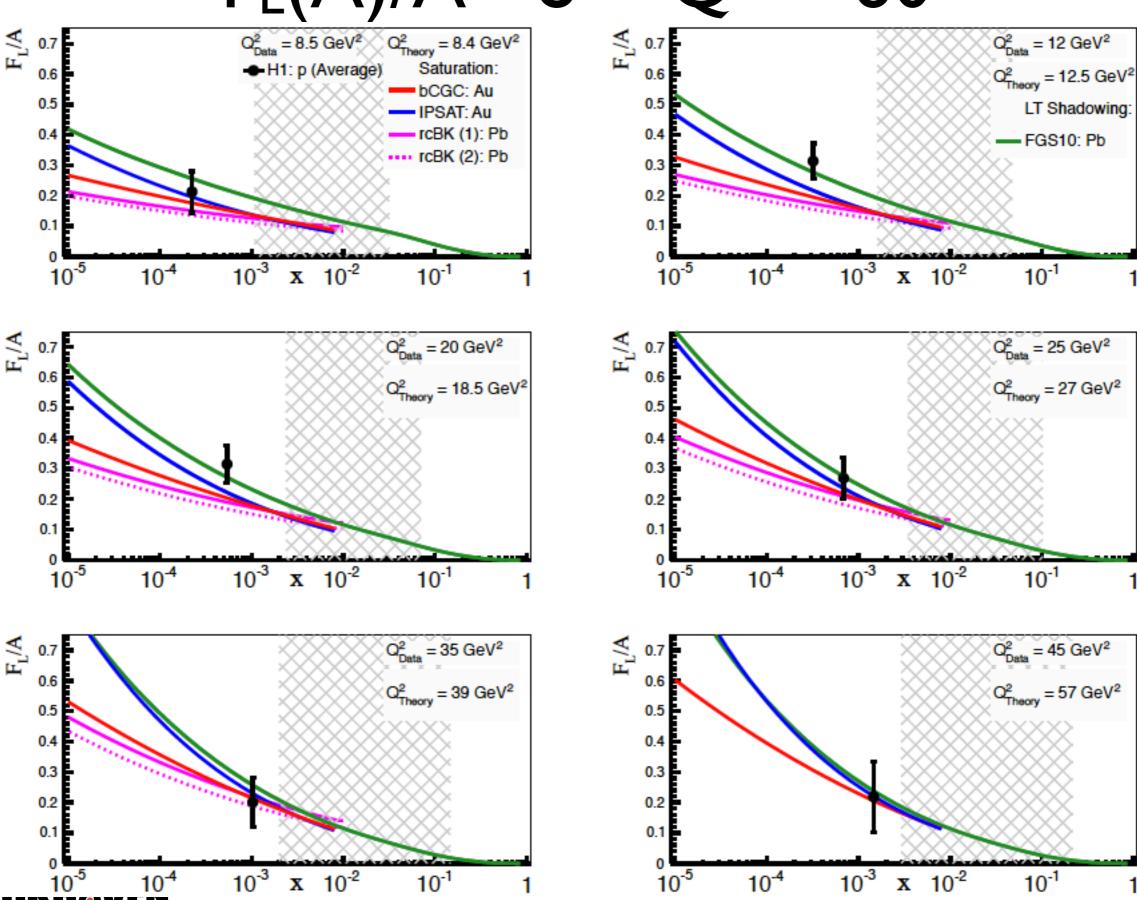
10⁻¹

10⁻⁵

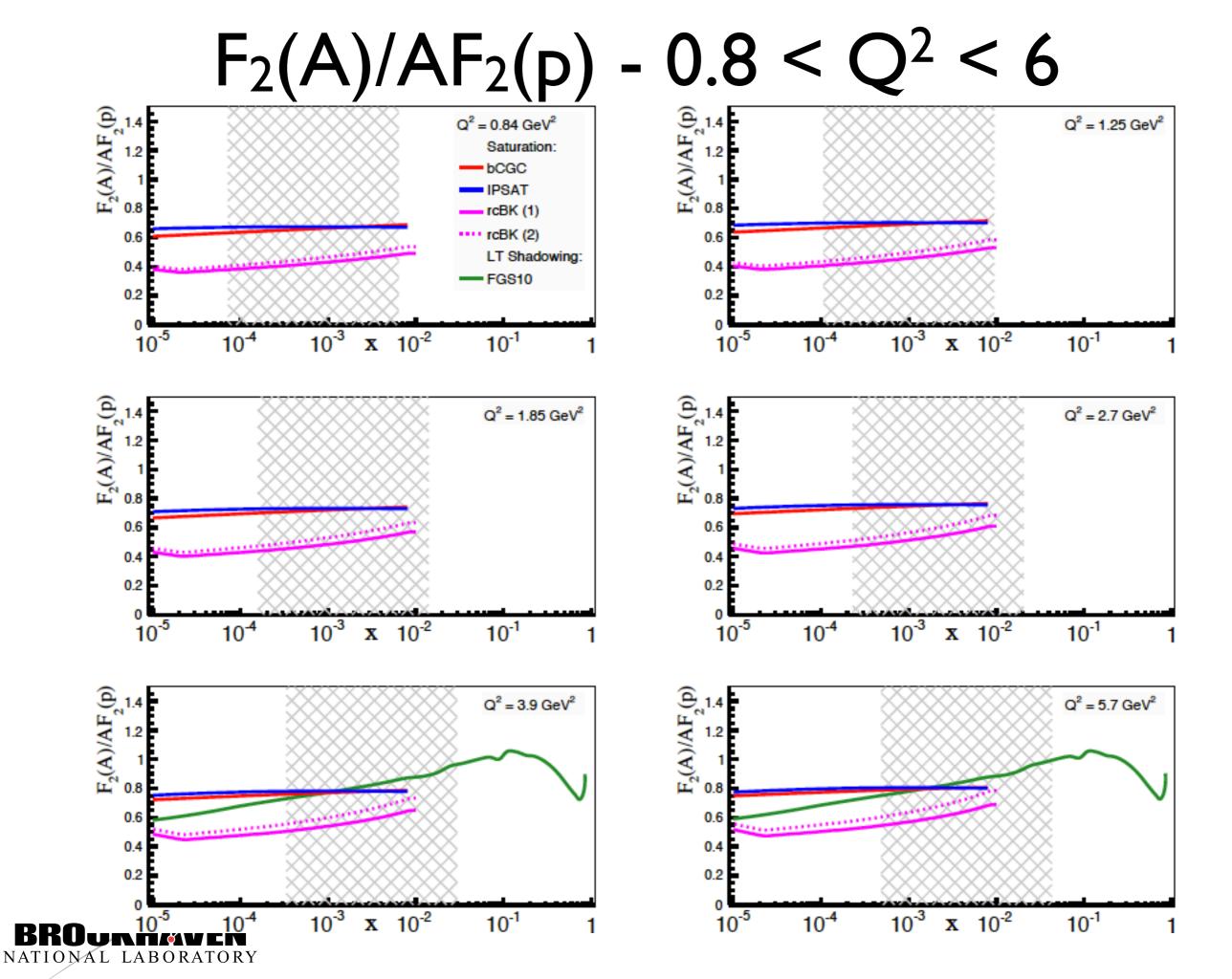
10⁻⁵

10⁻¹

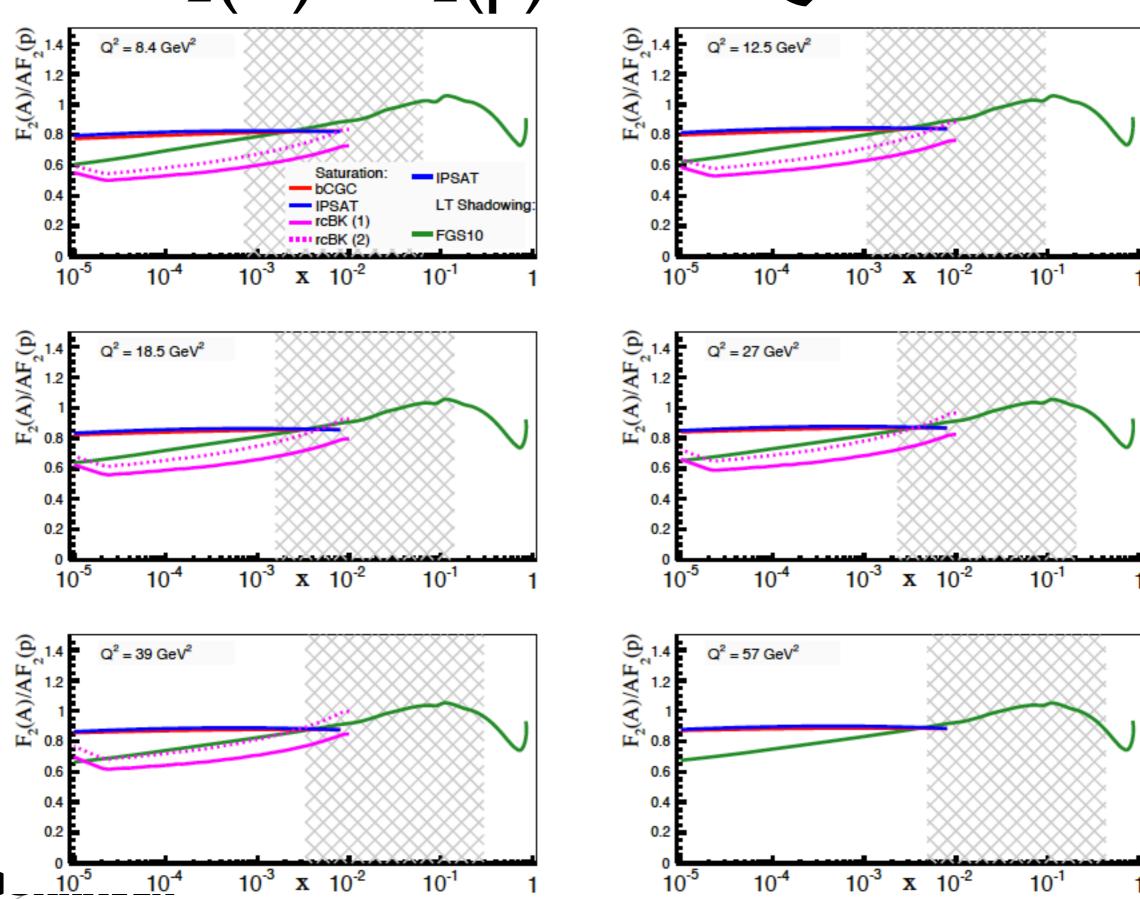
$F_L(A)/A - 8 < Q^2 < 60$



NATIONAL LABORATORY



$F_2(A)/AF_2(p) - 8 < Q^2 < 60$



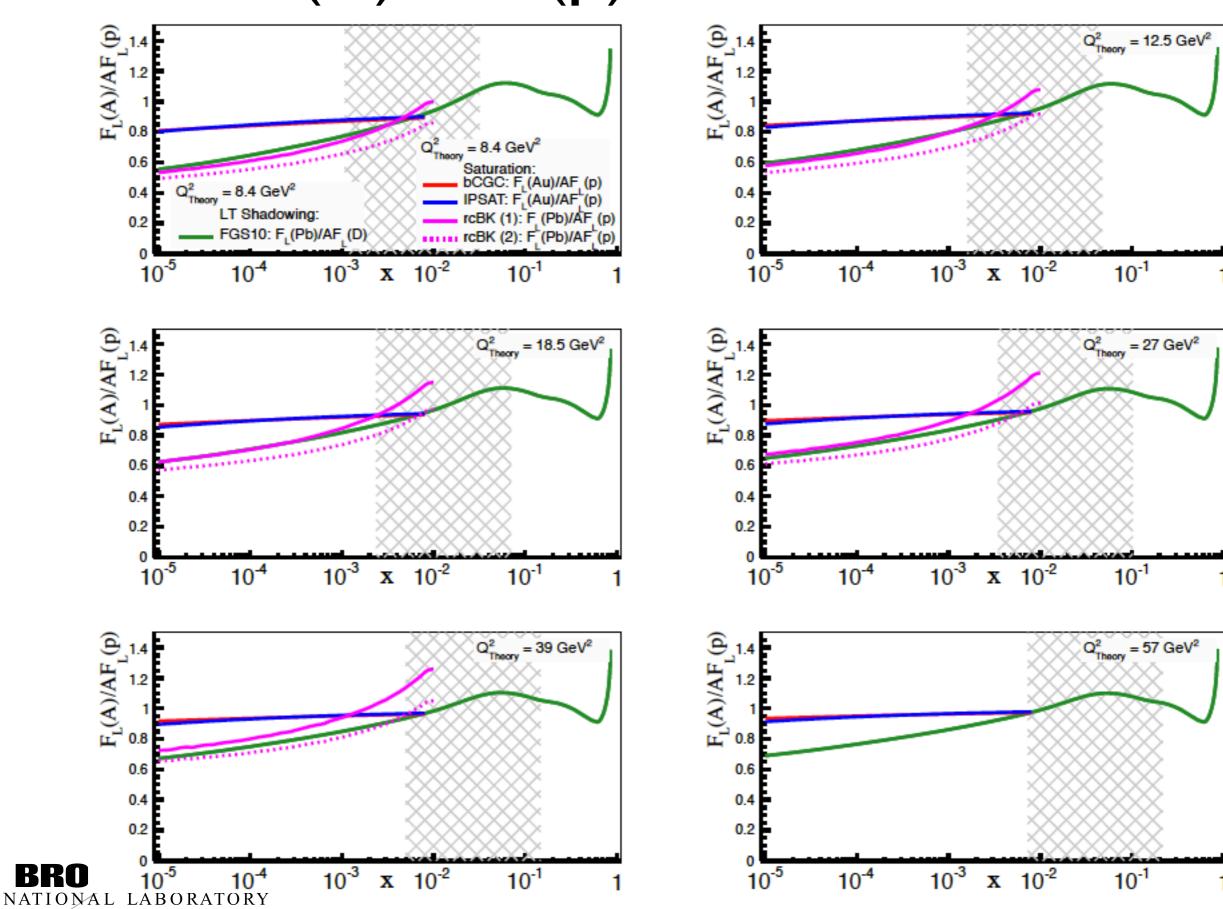
BRO

NATIONAL LABORATORY

$F_L(A)/AF_L(p) - 0.8 < Q^2 < 6$ (A)/AF (D)/AF (D $F_L(A)/AF_L(p)$ $= 0.84 \text{ GeV}^2$ $Q_{\text{Theory}}^2 = 0.84 \text{ GeV}^2$ $Q_{\text{Theory}}^2 = 1.25 \text{ GeV}^2$ Saturation: LT Shadowing: bCGC: F_L(Au)/AF_L(p) IPSAT: F_L(Au)/AF_L(p) FGS10: F_L(Pb)/AF_I(D) rcBK (1): F (Pb)/AF (p) rcBK (2): F (Pb)/AF (p) 0.6 0.6 0.4 0.4 0.2 0.2 0 10⁻⁵ 10⁻⁵ 10⁻⁴ 10⁻³ 10⁻² 10⁻³ x 10⁻² 10⁻¹ 10-4 10⁻¹ X F_L(A)/AF_L(p) F_L(A)/AF_L(p) 1.2 1.2 1.2 1.8 1.2 1.8 $Q_{Theory}^2 = 2.7 \text{ GeV}^2$ $Q_{Theory}^2 = 1.85 \text{ GeV}^2$ 0.6 0.6 0.4 0.4 0.2 0.2 0 10⁻⁵ 10⁻³ 10⁻⁵ 10⁻¹ 10⁻⁴ x 10⁻² 10⁻³ x 10⁻² 10-4 10⁻¹ F_L(A)/AF_L(p) 1.2 1.2 0.8 $Q_{\text{Theory}}^2 = 5.7 \text{ GeV}^2$ $Q_{Theory}^2 = 3.9 \text{ GeV}^2$ 0.6 0.6 0.4 0.4 0.2 0.2 10⁻³ 10⁻⁵ 10⁻⁵ x 10⁻² x 10⁻² 10⁻⁴ 10-4 10⁻¹ 10⁻¹ NATIONAL LABORATORY

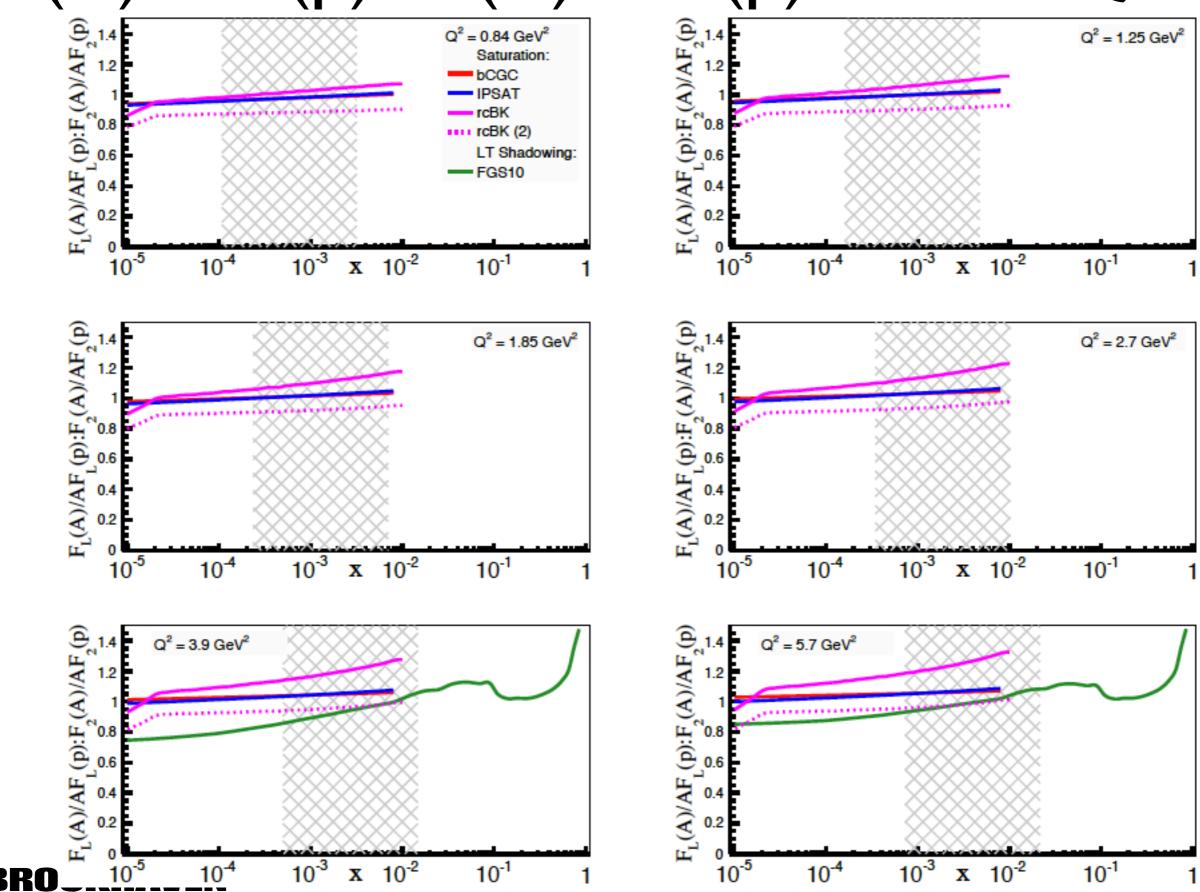
BRO

$F_L(A)/AF_L(p) - 8 < Q^2 < 60$



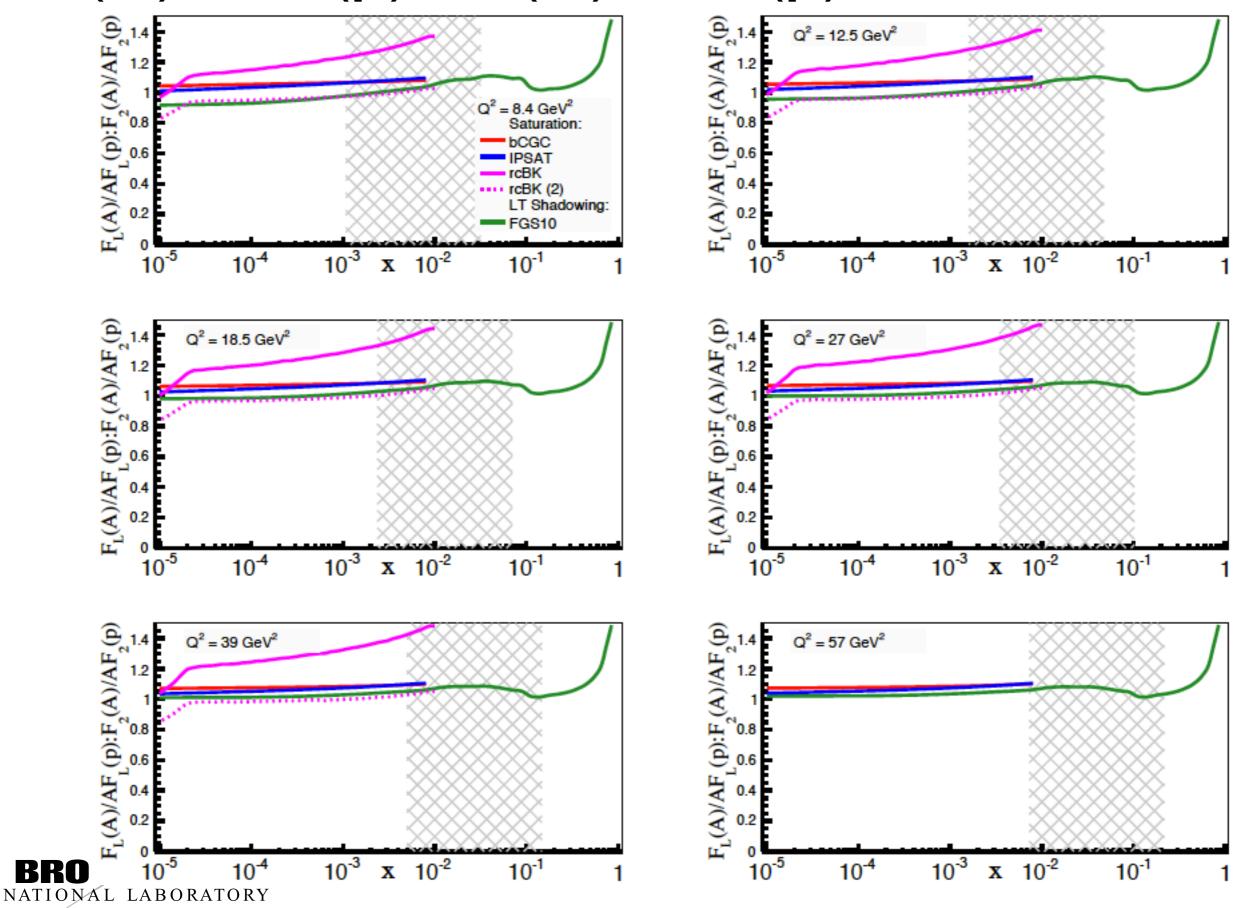
BRO

$F_L(A)/AF_L(p)$: $F_2(A)/AF_2(p) - 0.8 < Q^2 < 6$



NATIONAL LABORATORY

$F_L(A)/AF_L(p)$: $F_2(A)/AF_2(p) - 8 < Q^2 < 60$



Some Questions, Points, Thoughts

- The bCGC and IPSat models are different for F₂(p) and rcBK and bCGC are on top of each other
 - ⇒ bCGC and rcBK are based on BK IPSat on eikonalised DGLAP.... Was the bCGC re-fit to the combined H1&ZEUS data?
- There are 10% differences between IPSat and the F2(p) HERA data
 - If IPSat was re-fit (not a small effort, who would do it?), would this have any significant affect on the F_L data?
- What do we make of the difference in evolutions of $F_2(A)/AF_2(p)$ and $F_2(A)/AF_2(p)$ in the saturation models?
 - → Must be dependent on what order the saturation is implemented in the model
- The double ratios are hard to interpret, can we use this though to constrain the normalisations in the rcBK model?
- Vadim is currently updating his code to use CTEQ6/10 instead of CTEQ5
 - → How will this affect the plots?
 - → Will the ratios be unchanged (or at least minor changes)?
- Finally, we want some clean plots for the white paper, what do we want to show?

